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Identification of drivers, benefits, and challenges of ISO 50001 through case study content analysis

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ABSTRACT

An expanding body of research is defining drivers, benefits, and challenges of adopting ISO 50001 energy management systems. The Clean Energy Ministerial's Energy Management Leadership Awards program requires ISO 50001-certified organizations to develop case studies of their implementation experience. 72 recent case studies spanning multiple economic sectors provide a unique global look at implementation from certified organizations' perspectives. This dataset was investigated through content analysis of phrases related to motivations and goals, the role of management and the organization, benefits achieved, keys to success, and challenges. This paper presents findings from this quantitative analysis of "codes" assigned to phrases that capture their meaning. While organizations adopted ISO 50001 for different motives and saw myriad benefits beyond energy savings and associated greenhouse gas emissions reductions, commonalities exist. The most frequently identified drivers are existing values and goals, environmental sustainability, and government incentives or regulations. Findings also include: obtaining and sustaining top management support is critical; top benefits mentioned are cost savings, productivity, and operational improvements; and the primary barrier is lacking a culture of energy management. Policymakers and others looking to accelerate ISO 50001 uptake can use these findings to highlight benefits and incentives that will resonate with corporate decisionmakers worldwide.

1. Introduction

ISO 50001 is the international framework for the holistic and structured practice of managing energy. First published by the International Organization for Standardization (ISO) in 2011 and revised in 2018, the aim of ISO 50001 is to help organizations continually improve their energy performance via a systematic process of energy management. The standard specifies requirements for an energy management system (EnMS) that enables any organization to deepen and sustain improvements in its energy performance. By the end of 2017, more than 22,000 facilities worldwide had implemented ISO 50001 (ISO, 2018). Based upon analysis of the historical uptake of other major ISO management system standards including ISO 9001 and ISO 140001, uptake of ISO 50001 is anticipated to quicken as businesses incorporate energy management into supplier requirements and corporate sustainability strategies (Curkovic and Sroufe, 2011; Perkins and Neumayer, 2010).

A growing body of research is beginning to document the drivers for and barriers to ISO 50001 uptake. Fiedler and Mircea (2012) speculated that cost saving is "probably the major driver for the majority of organizations" putting an ISO 50001 EnMS into effect, achieved via lower energy costs and compliance with governmental financial incentives such as those in Germany, which lower electricity and energy taxes (Fraunhofer ISI 2017; DIN, 2013). They further suggest that certification "proves a sustainable company strategy … and strengthens its company image," but did not cite any data to bolster their assertions. Similarly, for a range of certified companies contending for Energy Management Leadership Awards, the Clean Energy Ministerial (2016 & 2017) presented a collection of employee quotes that touch on motivations and benefits of ISO 50001 implementation, along with associated energy and cost savings, facility locations, and industry sectors, but performed no analysis.

Several recently released surveys queried companies on the drivers, benefits, and challenges associated with ISO 50001 adoption. AFNOR (2015 & 2017) and Marimon and Casadesús (2017) collectively conducted online surveys of 308 ISO 50001-certified companies. AFNOR (2015) identified the following common drivers: obtaining certification, achieving methodical energy management, cost savings through managing energy, corporate strategy, available subsidies and financial support, and rising energy and/or carbon costs. 65% of organizations saw both financial and non-financial benefits, such as better identifying

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energy consumption zones to ultimately increase profit margins, prioritizing strategic actions, increasing personnel skill level, and triggering innovation. Building on 2015 findings, AFNOR (2017) concluded that ISO certification increasingly appeals to companies of all sizes, and that many (78%) surveyed facilities are certified in at least one other ISO area, most often 9001 (quality) or 14001 (environment). In descending order of prevalence, common drivers were: financial savings through systematic energy management, meeting or anticipating regulatory requirements, availability of government subsidies and financial assistance, company strategy, and the need to restructure existing processes. Finally, Marimon & Casadesús (2017) characterized the main drivers for implementation as ecological motivations, gaining competitive advantage, and social requirements. They found that positive results from ISO 50001 include monetary savings, motivating other organizations to implement the standard, improved environmental performance and safety, and better overall productivity. Critical to successful implementation were positive attitudes of company staff, while main challenges were the high cost of certification, data complexity, the lack of available resources and leadership commitment, and the uncertainty of benefits.

These recent surveys provide important insight into conditions that may predict successful implementation of ISO 50001. It should be noted, however, that 274 of 308 total respondents across these three surveys—or 89%—were located in three European countries (Germany, France, and Spain), a fraction significantly outweighing the share of certified facilities in those same nations: 51% (ISO, 2018). These are all advanced industrial economies part of the European Union and theoretically face markedly different conditions for implementation relative to the rest of the world, especially with regard to regulatory and financial incentives. Moreover, from limited information presented, the sampling method of these surveys appears to be neither random nor stratified, precluding high external validity. Ideally, a future random sample of companies that have attempted (and not necessarily achieved) ISO 50001 certification, with greater geographical reach, is required for more robust survey results.

This paper explores the case studies submitted by ISO 50001-certified companies for Energy Management Leadership Awards in 2016 and 2017 as a set of qualitative data that can be quantified through content analysis. The dataset developed for this paper draws from companies around the globe, representing a wide variety of industrial, commercial, and municipal sectors. The questions motivating this study are:

- Why do companies implement ISO 50001-certified energy management systems?
- What are the drivers, benefits, and challenges of ISO 50001 certification?
- What did ISO 50001-certified organizations experience, and are these experiences shared?
- What can we learn from these early adopters, and how might policymakers and other ISO 50001 advocates use this knowledge to better develop and direct communication materials to accelerate the uptake of ISO 50001?

2. Data and methods

2.1. Available data

With limited available information outside Europe on the drivers, benefits, and challenges of ISO 50001 implementation, case studies submitted as part of the annual Energy Management Leadership Awards program offer a globally diverse set of data directly from ISO 50001-certified companies. The Clean Energy Ministerial's Energy Management Working Group (EMWG) hosted the first annual awards ceremony in May 2016. To qualify for consideration, ISO 50001-certified organizations submitted a written case study using a template developed by the EMWG. Case studies typically ranged from five to nine pages in length; 35 organizations tendered case studies in 2016, and 37 in 2017. This analysis used all 2016 and 35 case studies from 2017, excluding two 2017 case studies due to reporting inconsistencies. Table 1 displays their sectoral and geographical reach, as classified by the Clean Energy Ministerial (2016 & 2017). Table 1 orders sectors and UN (2018) regions by facility count.[1]

Together, 72 case studies representing 204 facilities documented a total energy savings of 53 trillion Btus (56 PJ)[2] and associated cost savings of \$227 million. The CO_2 emissions reduction of 6.7 million metric tons[3] achieved by these facilities is equivalent to the emissions from 1.4 million passenger vehicles driven for one year.

2.2. Methodology

The collection of case studies included in this analysis encompass

Table 1
Sectors and countries represented in 2016 and 2017 case studies.

Sector	# facilities	# case studies
Manufacturing[a]	83	50
Insurance & property management	28	2
Oil & gas production	26	5
Technology & services	26	1
Energy & energy management products & services	21	2
Water & wastewater	8	2
Electric power generation	3	3
Telecommunications	3	1
Municipalities	2	2
Charity	1	1
Financial services	1	1
Freight transportation	1	1
Mining (gold & copper)	1	1
Totals	**204**	**72**

Region	Specific countries represented	# facilities	# case studies[b]
Europe	DE, ES, FR, HU, IE, IT, LV, PL, PT, UK	59	19
North America	CA, US	57	16
East Asia	ID, KR, PH, SG, TH, TW	30	20
Western Asia	AE, JO	27	5
Latin America	AR, BR, CL, MX	12	7
South Asia	IN	10	10
Africa	EG, ZA	6	6
Developed Asia & Pacific	AU, JP	3	3
Totals		**204**	**86**

[a] Specific manufacturing subsectors represented: general; cement; engines & related technology; automotive; chemicals; electrical equipment; food & beverage; pharmaceuticals; textiles; pulp & paper; acrylic film & battery; aluminum; automotive parts; commercial & defense nuclear; footwear; healthcare (diagnostics); iron, steel & fabricated metals; non-metallic mineral product; plastics; and safety equipment.

[b] Shows the number of case studies with a presence in each country, because some case studies pertain to multiple countries.

[1] *AE (United Arab Emirates), AU (Australia), AR (Argentina), BR (Brazil), CA (Canada), CL (Chile), DE (Germany), EG (Egypt), ES (Spain), FR (France), HU (Hungary), ID (Indonesia), IE (Ireland), IN (India), IT (Italy), JO (Jordan), JP (Japan), LV (Latvia), MX (Mexico), PH (Philippines), PL (Poland), PT (Portugal), SG (Singapore), SK (South Korea), TH (Thailand), TW (Taiwan), UK (United Kingdom), US (United States of America), ZA (South Africa).*

[2] *Several organizations did not report energy savings in their 2016 case studies.*

[3] *Several organizations did not report CO_2 emission savings in their 2016 case studies.*

several hundred pages of text, loosely structured by the case study template. One suitable approach to systematically extracting insights from this heterogeneous textual data is known as content analysis, a methodology used to make sense of qualitative data by enabling quantitative analysis. Frequently cited work covering important methodological considerations that this paper attempts to address are Elo et al., 2014, Lombard et al. (2002), and Stemler (2015), who introduces examples of content analyses amidst the explosion of "big data". Recent applications in the field of energy and environmental management appear to be quite rare; two examples are Nath and Ramanathan (2016) and Herbes and Ramme (2014). The main objectives of content analysis are transparency and a systematic, replicable approach. However, analysis of content necessarily involves interpretation, and it can be difficult to make any conclusions about hidden, or latent, content. This particular dataset also contains only successfully certified companies motivated to publicly promote their successes via an awards process, and thus is likely biased against a fuller accounting of challenges faced.

The application of content analysis to evaluate the content of these case studies occurs via close reading of each case study and manual transcription of phrases relevant to categories of interest defined as "Motivations and Goals", "Role of Management and the Organization", "Benefits Achieved", "Keys to Success", and "Challenges". Researchers

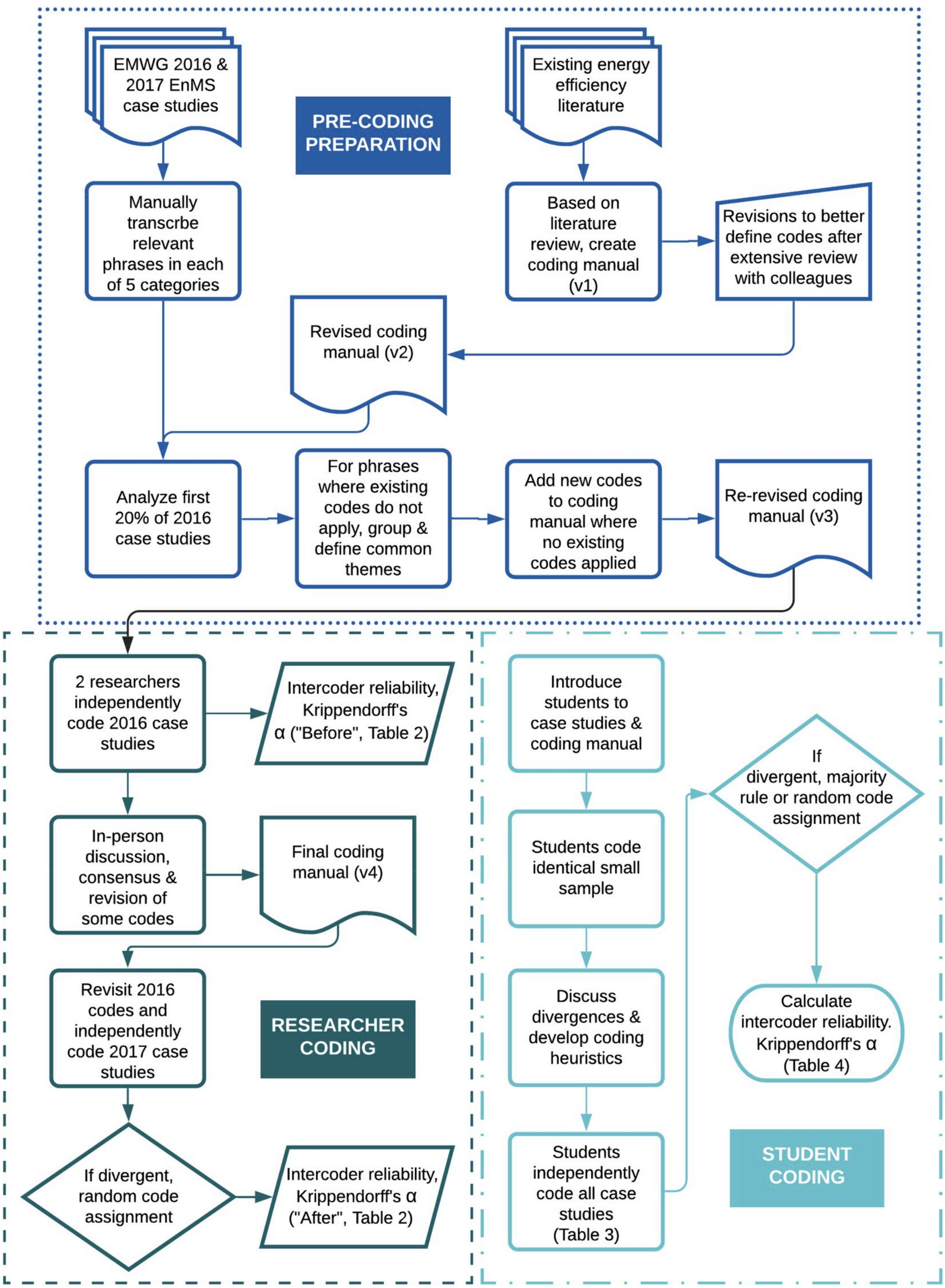

Fig. 1. Diagram of methodology for ISO 50001 case study content analysis.

used their best judgement in transcribing relevant phrases within each category, with the aim of avoiding the rote transcription of repetitive statements. The EMWG chose these categories based on their expected relevance to stakeholders interested in increasing the uptake of ISO 50001 energy management systems. In scoring the case studies, the highest possible points were awarded for discussion around the EnMS development and implementation (40 points), which mostly focused on the Role of Management and the Organization. The least amount of points was allocated to discussion about the business case for energy management (*i.e.,* Motivations and Goals), Keys to Success, and lessons learned (*i.e.*, Challenges). Each of those categories were assigned 5 points. The amount of content available for each section generally corresponded to the number of points allocated for that section, as case studies tended to focus more on sections worth more points.

Fig. 1 depicts the overall content analysis methodology. Researchers created a coding manual, which defines a number of "codes"—predetermined and well-defined categories—for each category of interest (see Appendix). Codes identify specified characteristics of each transcribed phrase, and analysis of these codes can quantify, for example, how often participating companies experienced certain motivations or benefits. Researchers determined some codes in advance via a conceptual framework and literature review of motivations, barriers, best practices, and behavior related to industrial and commercial energy efficiency. This review relied upon the works of Brun and Gereffi (2011), Environmental Defense Fund and Duke Center for Energy (2011), Sullivan et al. (2012), Straehle et al. (2013), Therkelsen and McKane (2013), U.S. Department of Energy (2015), and Luboff et al. (2016). Authors' colleagues with expertise in this area reviewed this first version of the coding manual in order to standardize the criteria of how each code related to its unique definition. Other codes emerged via analysis of the first 20% of the 2016 case studies to be transcribed. This approach, known as emergent coding, relies both on existing literature and on using data to guide theory, and lies between a wholly theoretical and an entirely empirical model (Stemler, 2015).

Reporting intercoder reliability is an essential precondition for validity of any content analysis (Lombard et al. 2002) in order to understand to what degree different coders would similarly assess the content of any given transcribed phrase and assign an identical code that represents its meaning. Krippendorff's alpha (α) was used as the intercoder reliability metric, as it controls for chance agreements and accommodates any number of coders, as well as missing values when one coder assigns multiple codes and the other does not (Hayes and Krippendorff, 2007).

Two researchers independently coded case studies, starting with those from 2016, by assigning each transcribed phrase the applicable three-to four-letter code or multiple codes where appropriate. Open-source Python code was used to calculate the intercoder reliability (Grill, 2017). Overall initial Krippendorff's alpha was 0.71. Extensive in-person discussion of discrepancies between how individual researchers assigned codes led to better consensus on codes' meanings, resulting in further revision of coding definitions. Researchers reevaluated 2016 code assignments and then independently coded 2017 case studies, leading to an overall Krippendorff's alpha for 2016 and 2017 case studies of 0.82. In case of remaining disagreement, researchers randomly chose one code among divergent assignments. Table 2 summarizes Krippendorff's alpha from this more preliminary analysis, with more detailed results available in Fuchs et al. (2018).

Based upon the review work of Neuendorf (2002), coefficients of ≥0.90 are always acceptable, those between 0.80 and 0.90 are satisfactory in most situations, and "below that, there exists great disagreement." A coefficient of 0.70 is usually deemed appropriate for exploratory research such as this, especially where the chosen metric is conservative in controlling for chance occurrences like Krippendorff's alpha (Lombard et al. 2002). Hayes and Krippendorff (2007) determined via a bootstrap sampling exercise that the "reliability standard" be set at a minimum value of $\alpha = 0.70$.

Table 2
Summary of intercoder reliability (Krippendorff's alpha), before and after code revision.

Category of interest	2016	2016+2017
	Before	After
Motivations and Goals	0.68	0.82
Role of Management and the Organization	0.73	0.83
Benefits Achieved	0.77	0.83
Keys to Success	0.68	0.79
Challenges	0.56	0.78
Overall	**0.71**	**0.82**

Before code revision, the only category with intercoder reliability significantly lower than 0.70 was Challenges. Given that all case studies focused on the success of implementing ISO 50001, very little information was available about difficulties faced during implementation. The lack of description and nuance around these challenges may have led to lower intercoder reliability for that category.

In pursuit of greater internal validity—where variations in results reveal differences in the underlying data in contrast to noise caused by analytical circumstances (Hayes and Krippendorff 2007)—results from five undergraduate student coders were solicited and tested to see whether they could reliably apply the coding scheme researchers had developed and refined. At the time coding occurred, these students were studying science, technology, engineering, and math (STEM) disciplines at a highly selective liberal arts college. They had been selected to participate in a two-week "externship" at the authors' research institution, one major component of which was coding the case studies. Because the nature of the externship program is primarily educational, researchers wanted students to code several categories of interest instead of only specializing in one or two. As a result, this content analysis design was not fully crossed (*i.e.*, it did not allow for systematic bias between coders to be controlled for), and may hence underestimate intercoder reliability (see Hallgren, 2012).

Student code assignment occurred in two stages, with the first serving as a reliability check. In the first stage, researchers introduced the coding manual and answered related questions. Each student received an identical small sample of case studies, with all categories visible, to code in accordance with the coding manual. Researchers then compiled students' code assignments before convening as a group to discuss questions related to differences that arose; in this meeting, the group decided collectively on heuristics of how to assign codes in similar instances.

The second stage involved each category being coded independently by three trained coders, according to the schema in Table 3. Five students were initially assigned the coding task, but one did not complete it. To ensure that each category was coded by the same number of people, the consensus codes from researchers' assignments were added as representing those of an individual third coder.

To uphold the integrity of the code assignment process, students were explicitly directed to 1) give precedence to careful reflection and accuracy, rather than speed; 2) assign codes independently of one

Table 3
Schema of category coding assignments for four students (A-D) and the research team (R).

Category of interest	2016 case studies			2017 case studies		
Motivations and goals	A	B	R	A	B	R
Role of management and the organization	B	C	R	B	C	R
Benefits achieved	C	D	A	C	D	A
Keys to success	D	A	R	D	A	R
Challenges	B	C	D	B	C	D

another, without conferring together; 3) consider each phrase as an independent unit, ignoring any knowledge they might possess of a particular firm or sector to evaluate each phrase; and 4) assign a maximum of three codes to each phrase, assigning multiple codes only in instances where one code did not adequately capture the meaning of a single phrase.

Finally, in order to determine which codes were ultimately assigned to transcribed phrases among multiple coders' sometimes divergent assignments, the rule of majority was first applied (*i.e.,* assigning the code that two of three coders chose), and where no majority existed, random chance was used to choose the final code. Krippendorff's alpha results from this second batch of code assignments are summarized in Table 4.

The work presented in this paper is experimental. Moreover, as mentioned earlier in this section, the Challenges sections of case studies contained the least information and was thematically more distinct from the rest of the text than any other section. Its low value of intercoder reliability should be understood in this context.

3. Results and discussion

Throughout this section, results are presented in bar charts, where the X-axis represents the codes mentioned and the Y-axis indicates the number of times concepts captured by those codes were mentioned across all case studies. The percentage atop each bar is the percentage of case studies mentioning those codes at least once. Fig. 2 exhibits all the codes across all categories in aggregate, excepting the codes mentioned in less than 50% of the case studies. All codes are defined in the Appendix. Note that some of the mentions of the same code could have different or opposite meanings depending on the section in which they appear (*e.g.*, an energy-aware company culture could represent either a challenge or a key to success). This figure is best viewed as the types of considerations most often mentioned across all categories.

Table 4
Measures of intercoder reliability, using Krippendorff's alpha; 1 indicates perfect agreement.

Category of interest	Krippendorff's α
Motivations and goals	0.72
Role of management and the organization	0.72
Benefits achieved	0.75
Keys to success	0.63
Challenges	0.40
Overall	**0.69**

The below table defines the codes shown in Fig. 2.

Code	General Description
CUL	An energy-aware company culture
CEO	Engagement and support of upper-level management
EX	Existing goals and values; previous energy efficiency achievements
$	Cost savings; return on investment
AWAR	Employee awareness through communication and transparency
INFO	Reliable and accurate energy metering; understand significant energy uses (SEUs) and identify facilities with largest impact
SUST	Environmental sustainability
SILO	Overcome organizational silos (*e.g.*, cross-departmental teams, share best practices)
TRN	Organize and sponsor relevant trainings
COLL	Collaborate with government, utility, or other outside entities for funding and knowledge
TEAM	Dedicated energy teams and appointment of internal champions with clear accountability
PR	Visibility, marketing value, and company image
PROD	Increase productivity (*e.g.*, via less plant downtime or lowering energy intensity)
GOV	Government incentives or regulations; partnership with organizations such as UNIDO
SYS	ISO 50001 provides a structured framework and tools to achieve energy goals

Fig. 2 visually demonstrates that the content analysis of more than 500 pages of written case studies yields quantifiable results from a qualitative dataset. Further examination reveals that this chart contains 15 of 66 total unique codes, meaning that approximately one quarter of unique codes developed were mentioned by at least half of the pool of 2016 and 2017 case studies. Also, the number of times concepts were mentioned—displayed on the Y-axis—generally, but not always, tracks in step with the percentage of case studies that mentioned each code at least once, which is displayed above each bar. Divergences are

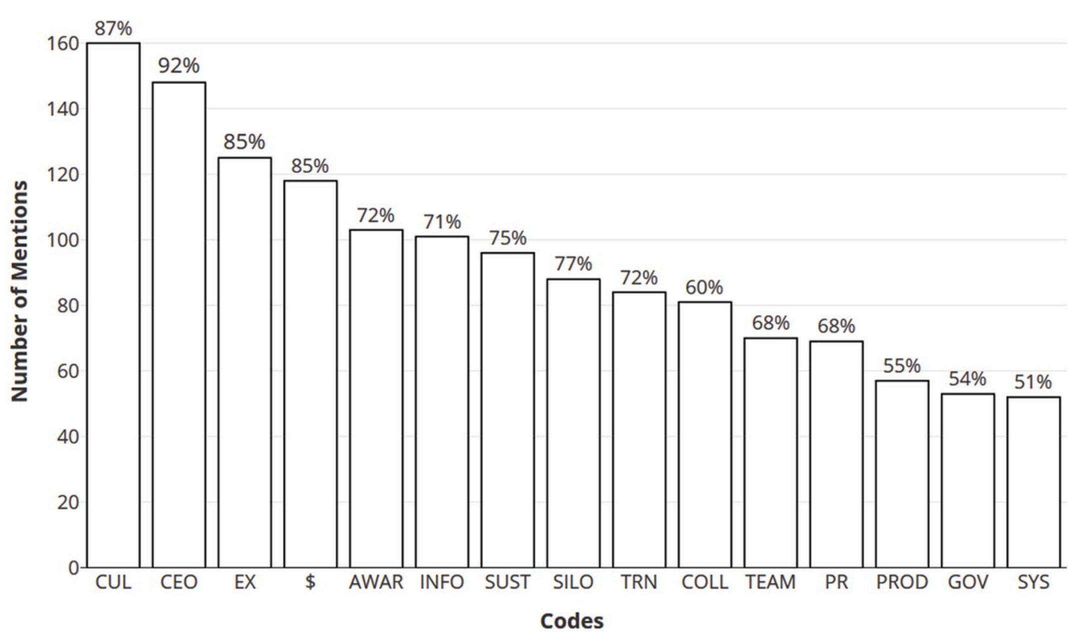

Fig. 2. All codes across all categories mentioned at least once in ≥50% of case studies; data includes case study submissions from 2016 and 2017.

attributable to case study authors stressing certain salient points more than once, and/or because the phrases encapsulated by certain codes lent themselves to more detailed textual description.

Considering in aggregate all the codes in Fig. 2, an energy-aware culture, engagement and support of upper-level management, existing goals and values, and cost savings were among the topics most discussed. The number of mentions for an energy-aware culture and engagement/support of upper-level management clearly outpaces those of existing goals and values and cost savings, yet the percentage of case studies mentioning each code ranges narrowly from 85–92% for these most common codes.

As mentioned earlier, information extracted from case studies fell under five categories ("Motivations and Goals", "Role of Management and the Organization", "Benefits Achieved", "Keys to Success," and "Challenges"). Fig. 3 summarizes the top five codes in terms of the greatest number of mentions within each category, which are also the top five codes by percentage of case studies mentioning those codes. The following subsections contain discussion of each category in more detail.

3.1. Motivations and goals

The results in Fig. 3a suggest that among the most important motivations for implementing ISO 50001 energy management systems are existing energy goals and values, environmental sustainability, government regulations and/or incentives, cost savings, and improved company image. Existing energy goals and values are the most common driver, both in terms of absolute number of mentions and percentage of case studies (72%). Environmental sustainability, government regulations and or/incentives, and cost savings cluster together when it comes to both number of mentions and percentage of case studies referencing these motivations (48–54%). Still among the top five of fourteen possible drivers identified, but exhibiting fewer mentions among fewer case studies (37%), is improving company image and marketing value.

Although cost savings were mentioned as a motivation less often than existing energy goals and values, the former was the most commonly mentioned benefit of ISO 50001 energy management systems (see Section 3.3). Stakeholders may thus wish to emphasize the primacy of cost savings as a proven benefit to motivate organizations deciding to pursue ISO 50001 certification. Finally, in the body of case studies, improving company image was often linked to improving competitiveness. Such experiences may serve to convince firms that publicizing ISO 50001 implementation could strategically position certified organizations above their competitors.

3.2. Role of management and the organization

Because ISO 50001 is a framework integrated into the management practices of an organization or facility, the role of management and the organization is paramount in its successful implementation. As seen in Fig. 3b, obtaining top management support or corporate-level commitment for ISO 50001 is first in this category, both in terms of number of mentions and percentage of case studies. Generally, management support was critical to ensuring that planning and implementation processes were well-resourced, roles and responsibilities on the energy team were clarified, and that energy management became integrated into company culture.

The essential role of the organization in arranging and delivering relevant trainings comes second. Training topics ranged from user training on energy awareness, energy behavior, and details of ISO 50001, to energy manager certification or expert training of enterprise energy managers. Recipients of training were varied as well and included top managers, energy team members, all employees, and employees whose daily practices most affect plant energy consumption. Such training often was provided by third parties such as consulting firms or government programs. The higher number of mentions for training may be attributable to the fact that many case studies described

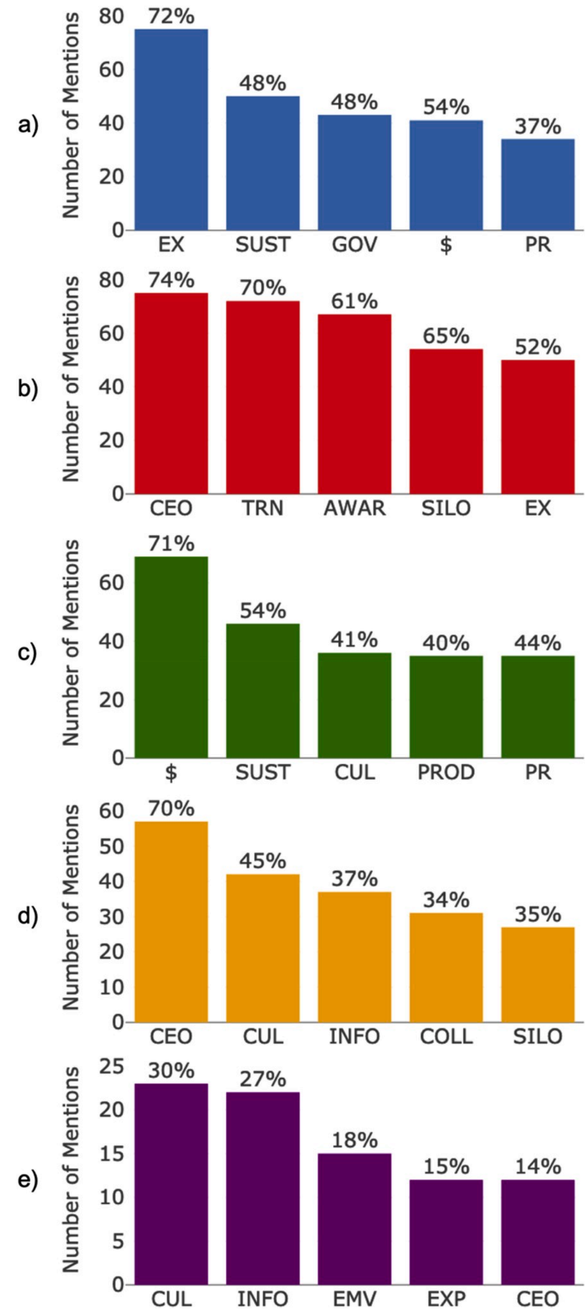

Fig. 3. Top five codes mentioned in each of the five categories for which the case studies were analyzed. a) Motivations and Goals, b) Role of Management and the Organization, c) Benefits Achieved, d) Keys to Success, and e) Challenges.

various types of trainings aimed at different actors within companies (*e.g.*, certified energy managers, energy team members, management, and process workers).

Actively taking measures to increase employee awareness comes next but is outpaced by the necessity of overcoming organizational silos when it comes to percentage of case studies (61% vs. 65%). Examples of specific steps taken to increase energy awareness are trainings, electronic campaigns conveying practices put into place via ISO 50001 and resultant energy savings (*e.g.,* e-mails, blog posts, newsletters, and periodic reports), visual communication materials (*e.g.,* posters reinforcing the benefits of energy management), annual energy awareness weeks or energy fairs, and energy-saving tips affixed to employee badges.

Last is having energy management as an existing goal, or having an existing framework (*e.g.,* ISO 14001 or similar) that can readily be

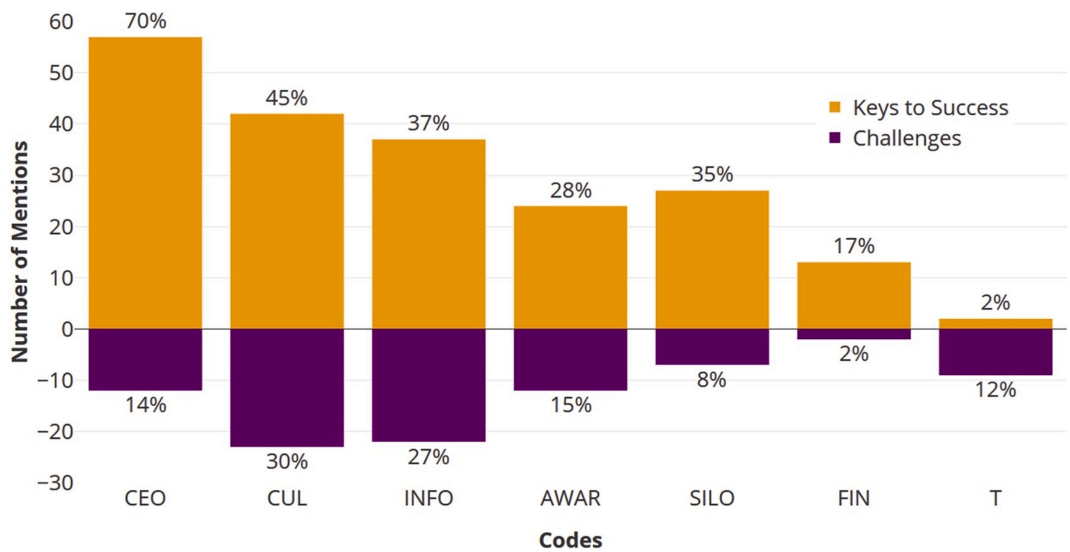

Fig. 4. Overlapping codes between "Keys to Success" and "Challenges".

modified to accommodate an EnMS, though this latter theme saw fewer mentions than did employee awareness efforts. Management often positioned ISO 50001 as the preferred option to achieve existing energy-related values, especially given the presence of existing management systems with a focus on continuous improvement. These were regularly cited as critical to quickening and simplifying ISO 50001 execution.

3.3. Benefits achieved

Although Fig. 3a identifies cost savings as only the fourth-most important motivation for adopting ISO 50001, Fig. 3c demonstrates that 71% of organizations characterized reduced cost as an important benefit. The next most frequently mentioned benefits in case studies were improved environmental sustainability, a stronger company culture, increased productivity, and improved company image—with 40–54% of case studies noting these. Here, increased productivity is defined as unit of output per unit of input, and can arise from less plant downtime, greater plant capacity, better energy intensity, or time and/or resource savings gained from automating processes or data collection. Case studies most commonly referenced environmental sustainability with respect to reducing greenhouse gas emissions.

Better employee motivation, strengthening company culture, and creating a culture of continuous improvement (all encapsulated in the code CUL) is one of the top benefits, mentioned by nearly half of the organizations that submitted case studies. It is important to note that promoting a culture of energy efficiency awareness was identified in 47% of case studies as a key task for management and the organization in facilitating the adoption of ISO 50001.

3.4. Keys to success

The term and content for "keys to success" is taken from the section of the EMWG case study template of the same name. In the template, this section recommends a bulleted format for the top tips and insights to help others successfully execute ISO 50001. Top keys to success can be seen in Fig. 3d. Strong management support was by far the most vital to successful uptake, as coded from almost three quarters of case studies. Developing an energy performance-focused culture with engaged employees received the second-most mentions and was key for 45% of participating companies. Next, more than one third of case studies analyzed featured three additional keys to success: the availability of high-quality energy data, collaboration with outside entities (*e.g.*, service providers, government, or implementation coaches), and reducing departmental silos.

Looking more closely at case studies that emphasize strong support from management, it becomes clear that because instituting a systematic EnMS requires time as well as financial and human resources, for best results senior management should establish well-defined energy policies and targets, allocate appropriate resources, and stay interested and involved in the ISO 50001 effort. Multiple firms learned that it is advisable to treat energy awareness as a mindset integrated tightly into employee behaviors, instead of viewing the EnMS solely as a system implementation or merely as a formality.

Case studies discussed energy data availability across various dimensions, including increasing knowledge of equipment and systems via real-time sub-metering, identifying significant energy uses to capture the best opportunities for energy efficiency investment, creating tools and databases that allow the evaluation of energy consumption in relation to certain variables, and having a direct link between operational control and monitoring phases, which allows informed decisions to be made based upon specific performance indicators. Measures taken to overcome organizational silos were also heterogeneous in nature, but often involved ensuring that dedicated energy teams were cross-functional and drawn from various departments; energy teams developing strong partnerships with finance departments; intensive (and sometimes top-down) communication; and sharing best practices between plants or facilities. Finally, participating companies advised collaboration with outside actors such as external consultants, peer companies or municipalities, government energy agencies/ministries, or organizations like UNIDO, in order to access effective technical expertise, energy audits, and training programs.

3.5. Challenges

Interpreting analytical results for challenges faced during implementation, presented in Fig. 3e, requires caution. 80% of the case studies mentioned at least one challenge, yet no single code was mentioned in more than one third of case studies that discussed any challenges, meaning that individual organizations discussed a narrower range of challenges compared to other categories. Given that case studies were from facilities that attained ISO 50001 certification in order to receive an achievement award, it is not unexpected that each organization will highlight successes rather than challenges. In addition, the EMWG template did not award points for discussing challenges specifically, relative to other items suggested in the "Lessons Learned" section, such as plans to replicate or expand ISO 50001 efforts at other sites, or solutions to challenges and measures for success.

Nearly one third of the case studies identified absence of an energy management culture as a major challenge. Concerns about culture typically revolved around the challenges in sufficiently engaging plant personnel to motivate them to care about energy, institutionalizing necessary behavioral changes, and maintaining synergy and commitment throughout. Next, 27% of all case studies identified insufficient energy consumption data. From EMWG awardees, this can take shape as a lack of availability, accuracy, and connectivity of power meters; difficulties setting up or maintaining an effective monitoring system; issues surrounding energy data transfer, security, and confidentiality; and the challenge inherent to identifying and prioritizing major energy consumers.

Other challenges include conducting energy measurement and verification, as well as lack of experience or in-house expertise with regards to ISO 50001 execution. Among participating companies, gaps in expertise were identified with respect to technical knowledge to manage energy, familiarity with ISO 50001 requirements and details of energy management systems, and finding a qualified accreditation body. Lastly, a lack of ongoing management support was mentioned as a challenge by 14% of all case studies. This involved overcoming management's initial disinterest or reluctance, driven by a narrow focus on increasing production, revenue, and profitability, as well as a lack of awareness of energy efficiency benefits for these targets. Common strategies to meet such a challenge were positioning ISO 50001 explicitly as a way to meet strategic challenges, starting with no- and low-cost projects, and showcasing smaller projects' success to ensure continued resource allocation.

3.6. Comparing keys to success and challenges

Additional findings are revealed when results from the "Keys to Success" and "Challenges" sections are compared simultaneously. Fig. 4 summarizes all codes where those two categories overlap. These codes are important to highlight because they are not only barriers to implementation, but can also be turned around to be used as an organizational strength for effective ISO 50001 adoption. In other words, themes represented here are vital to success—but also can be difficult to effectively harness. Note again that because the case study template placed little emphasis on challenges, the percentages for the bottom half of Fig. 4 may understate impediments to successful EnMS adoption.

The below table defines the codes shown in Fig. 4.

Code	Description - Keys to Success	Description - Challenges
CEO	Support from management; corporate-level program leadership	Lack of ongoing top management support
CUL	Existing culture of energy awareness; recognition that energy conservation is a responsibility and part of everybody's work	Energy management not integrated/rewarded within company culture, nor is part of daily employee behavior
INFO	Reliable and accurate energy metering; understanding SEUs and identifying facilities with largest impact	Imperfect information; lack of disaggregated and transparent energy consumption data
AWAR	Specifically take measures to increase employee awareness and improve transparency and reporting	Lack of awareness or failure to recognize benefits of systematic EnMS or non-energy benefits
SILO	Reduce departmental silos; create cross-functional energy teams; share required tools, frameworks, and information	Departmental silos; misaligned responsibilities & budgets; knowledge gap between departments
FIN	Commit sufficient resources; give program its own budget responsibility	Internal competition for capital
T	Minimize implementation time	Time commitment required for learning/implementation

Nearly three quarters of all case studies emphasized the necessity of top-level management support, with 14% identifying the same as a challenge. Relative to top management support, an energy-aware culture was next most prevalent as a key to success, but fostering such a culture was more often identified as a challenge than was securing management support. Gathering accurate and sufficient energy data was identified as critical to success about as often as was reducing departmental silos through various measures (in terms of percentage of case studies)—yet participating organizations mentioned encountering difficulties in energy data and monitoring three times more often than they noted overcoming silos. Specifically taking measures to increase employee awareness of energy can be viewed as complementary to creating an energy-aware culture; smaller shares of case studies identified this theme as both a challenge and a key to success. In many cases, a challenge assigned one code (*e.g.*, FIN) would be potentially resolved by a key to success coded differently (*e.g.,* CEO). For example, in one case study changing the company culture to integrate energy management was a challenge met by specific actions to improve communication, awareness, and competencies.

4. Conclusions and policy implications

Because the ISO 50001 standard is relatively new compared to other major ISO management standards such as ISO 9001 and ISO 14001, little evidence exists of well-defined value propositions for instituting an ISO 50001 energy management system. In part because this standard can be implemented in heterogeneous organizations of all types, sizes, sectors, and geographic locations, there is a scarcity of data in existing literature, especially outside of Europe, on the drivers, benefits, and challenges of implementation—making it difficult to clearly communicate the business value of ISO 50001.

In applying the method of content analysis to a collection of case studies authored by organizations certified to ISO 50001 and contending for Energy Management Leadership Awards, commonalities were found amongst the range of drivers, benefits, and challenges that these organizations experienced when adopting ISO 50001. These findings represent the creation of new knowledge in the nascent field of understanding motivations for systematic energy management, and can be leveraged by policymakers and industry ISO 50001 advocates alike to accelerate uptake of ISO 50001. In addition, the scientific community may benefit more broadly by applying similar analytic techniques to existing collections of qualitative data in order to yield new insights.

Of course, these results are subject to certain limitations of the content analysis method. First, determining which phrases from case studies are relevant to the analysis, and assigning meaning to transcribed phrases, inescapably entails some subjectivity. For example, while researchers strove to avoid the inclusion of repetitive material in their transcription, it is impossible to say whether repeated mentions of codes imply that companies are more aware of these factors. Second, researchers can only infer conclusions from the content that case study authors chose to include. With respect to the particular set of data analyzed here, the focus on emphasizing success—given that case studies were written in pursuit of energy management awards—makes it difficult to attain a nuanced understanding of difficulties faced while implementing ISO 50001. In addition, results of content analysis are more robust with larger datasets. Finally, taking a quantitative approach to a qualitative dataset can exclude more nuanced interpretations. Indeed, the authors do not suggest that this analysis should replace case studies of 50001 implementation, but that it is viewed as complementary to them.

However, methods to ameliorate these constraints do exist. Content analysis practitioners can reduce the influence of subjective inferences by making the process more objective and systematic. For example, in this case two researchers independently coded the data, followed by four undergraduate students doing the same, and associated intercoder reliability metrics are calculated and presented. Because this work is novel in its application of the content analysis technique to the field of energy management systems implementation and is thus exploratory research, the results presented in Section 3 can be considered to be reasonably robust.

From this analysis, the biggest motivations for ISO 50001 certification are: existing values and goals, cost savings, environmental sustainability concerns, government incentives or regulations, and gaining competitive advantage via visibility. These are largely aligned with those from recent European surveys (AFNOR, 2015/2017 and Marimon and Casadesús, 2017). Given these insights, policymakers may want to position ISO 50001 as a proven means to achieve existing energy and sustainability strategies while enhancing company image and competitiveness. Of these motivations, cost savings and improving environmental sustainability were commonly seen as benefits.

As a result of this work, prime candidates for ISO 50001 are companies that have already articulated an energy vision, taken steps to improve operational energy efficiency, or include environmental sustainability among their core values. Similarly, organizations with existing energy and sustainability goals and values can look to ISO 50001 as a way to achieve those aims. To a lesser extent, organizations that are looking to improve their public image and save on energy-related costs will benefit from ISO 50001. In order to accelerate uptake of ISO 50001, policymakers may want to target communication materials highlighting ISO 50001 as a mechanism that companies can use to achieve external goals and sustainability objectives. Half of the companies who submitted case studies mention government regulations and/or incentives as a motivating factor in their decision to pursue ISO 50001 certification.

The role of management and the organization in establishing a successful ISO 50001 EnMS is vital to success. Three quarters of case studies referenced the importance of management buy-in and commitment to the success of ISO 50001. Initial commitment and ongoing interest from top management help ensure that the implementation process has the resources it needs and is able to transcend company silos by establishing cross-functional teams, with clear lines of communication between departments and facilities.

Organizations submitting case studies demonstrated energy savings as detailed in section 2.1, fulfilling perhaps the most straightforward objective of the ISO 50001 standard. However, while three quarters of case studies mentioned related cost savings as a major benefit of ISO 50001 implementation, it was the so-called "non-energy benefits" of meeting sustainability objectives, organizational cultural and employee morale, along with productivity and public relations improvements, that consistently came up as the realized benefits of ISO 50001 implementation. The ISO 50001 process benefits an organization by fostering a culture of continuous improvement and energy efficiency awareness, which in turn makes it easier for management and the organization to execute future improvements. Participating companies realized increased productivity via less plant downtime, higher capacity, better energy intensity, and/or by automating energy monitoring or management processes.

Keeping in mind that the data for this paper are solely based upon supplied case studies that fundamentally are intended to highlight success, common challenges to ISO 50001 implementation were mentioned. Stiff cultural resistance and difficulty in educating personnel up and down the organizational structure were identified in nearly one third of case studies. With less frequency, challenges related to calculating energy savings, having sufficient in-house expertise and/or accessing external know-how, and sustaining top management commitment were identified as barriers to ISO 50001 implementation. Policymakers should look to make technical resources known to facilities and provide to executives informational materials about the value of ISO 50001. For some organizations, the time-intensive process of educating management and staff about the energy and non-energy benefits of ISO 50001 will be a barrier that policymakers and other interested parties can help address. Competitive pressure as ISO 50001 gains traction should help to reduce these barriers as the benefits realized by competitors are obverse.

Ultimately, the keys to success as found in case studies hinge on the engagement of top management, a culture of continual improvement and recognition that energy is important to the organization, sharing information, and the ability to engage across business units within an organization. Policymakers and others promoting ISO 50001 should develop educational material and conduct outreach to top managers highlighting the energy and "non-energy" benefits of ISO 50001. Top managers can actively take measures to increase employee awareness to advance a culture of energy conservation, while ensuring trainings and detailed energy data collection are conducted in order to equip their organization's workforce to effectively manage energy and strive for continuous improvement, the hallmark of ISO 50001.

The analysis in this study can be improved upon with inclusion of 2018, 2019, and future year case studies. Development of a publicly accessible database quantitatively and qualitatively detailing the drivers, successes, challenges, and keys to success from this and other studies, coupled with "sound bite" testimonial quotes that speak to business units within various organizations, will further aid those seeking to promote uptake of ISO 50001 to individuals within organizations.

Author contribution statement

Heidi Fuchs: Methodology, Validation, Investigation, Writing – Original Draft, Writing – Review & Editing, Visualization, Project Administration.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix. Coding Manual

This coding manual includes all defined codes used in this analysis. The manual is organized first by category of interest and alphabetically by code within each category. Codes are in the left column, with definitions on the right. Some categories of interest are further broken down into subcategories.

Motivations and Goals

$	Cost savings; return on investment
BUS	New product development, business models, or business opportunities
COMP	Increase competitiveness; business performance-related issues
CSR	Corporate social responsibility; consumer, shareholder, or buyer pressure to be green
CUL	Strengthen company culture; improve employee awareness of and motivation for energy savings
EX	Existing goals and values; previous energy efficiency achievements
GOV	Government incentives or regulations; partnership with organizations such as UNIDO
ISO	Positive results from previous implementation of other ISO management systems (or similar)
PR	Improving image and marketing value; brand protection; gain competitive advantage via visibility
PROD	Increase productivity (*e.g.,* via less plant downtime or lowering energy intensity)
QUAL	Better product quality
STAB	Economic stability by reducing exposure to volatility; risk reduction; improve business sustainability
SUST	Environmental sustainability
SYS	ISO 50001 provides a structured framework and tools to achieve energy goals

Role of Management and the Organization

AWAR	Actively take measures to increase employee awareness through communication and transparency
CEM	In-house presence of certified energy managers
CEO	Top management support or corporate-level commitment
COLL	Collaborate with government, utility, or other outside entities for funding and knowledge
CUL	Involve all employees in creating an energy-aware culture; energy management is everyone's responsibility
EED	Consider an energy-efficient design from the start of each project
EMP	Empower and reward employees for taking action
EWA	Enterprise approach to streamline efforts at various facilities
EX	Energy management as an existing goal; existing ISO 14001 or similar framework(s)
FIN	Dedicate funds and resources outside individual groups' budgets; use financial approach beyond simple PBP
INFO	Develop energy metering plan for reliable and accurate data; understand significant energy uses (SEU)
INT	Rely on internal resources and in-house capabilities
METR	Determine appropriate metrics (*e.g.,* energy performance indicators, baselines, and benchmarks)
NCAP	Focus on low or no-capital projects
SILO	Overcome organizational silos (*e.g.,* cross-departmental teams, share best practices among facilities)
SUPP	Engage with suppliers or others in supply chain around energy policy
TEAM	Dedicated energy teams and appointment of internal champions with clear accountability
TRN	Organize and sponsor relevant trainings

Benefits Achieved

$	Cost savings; return on investment
BUS	New product development, business models, or business opportunities
CEO	Solidified management support for energy management and energy efficiency
COLL	Better relationship with governments, utilities, peers, and other partners
COMP	Increased competitiveness
CSR	Achieved existing corporate sustainability or social responsibility goals
CUL	Better employee motivation; strengthened company culture; built culture of continuous improvement
EQP	Increased service life of machines and equipment
GOV	Achieved compliance with existing or impending regulations or external governmental commitments
INFO	Better information about energy, cost, plant processes, and SEUs; automated data collection
ISO	Helped comply with other ISO standards (given that overlap exists)
JOBS	Created new jobs
NCAP	Energy savings through low or no-capital projects
OTH	Improved other processes not related to SEU (*e.g.,* maintenance, procurement, occupant comfort)
PR	Enhanced visibility, marketing value, and company image
PROD	Increased productivity via less plant downtime, higher capacity, better energy intensity; time/resource savings via automation
QUAL	Better product quality
RES	Identified opportunities to save other resources used (*e.g.*, water, nitrogen)
SAFE	Achieved safety benefits
STAB	Improved economic stability; reduced risk/exposure to energy costs
SUST	Improved environmental sustainability; increased use of renewable resources
SYS	Established process, tools, and consistency for managing energy and data; good methodology for energy review and planning
WFD	Workforce skill development and knowledge enhancement

Keys to Success

General	
CEO	Support from management; corporate-level program leadership
CONS	Consistency of effort; concept of continuous improvement
INFO	Reliable and accurate energy metering; understanding SEUs and identifying facilities with largest impact

(*continued on next page*)

(*continued*)

PORT	Portfolio approach, where projects are aggregated across global operations
SIMP	Keep planning and implementation as simple as possible
Goal Setting	
AWAR	Specifically take measures to increase employee awareness and improve transparency and reporting
CLR	Clearly stated strategic targets and corporate goals for energy efficiency
CUL	Existing culture of energy awareness; recognition that energy conservation is a responsibility and part of everybody's work
REL	Relative goals, which allow more flexibility
STAB	Anchor EE efforts in a broader evaluation of organizational risk and commercial feasibility
T	Minimize implementation time
TIME	Think on a longer time horizon, as energy management requires long-term planning
Identification of Opportunities	
COLL	Collaboration with service providers, government, or implementation coaches; access to guidance documents
NCAP	Focus on low or no-capital projects (*e.g.,* behavioral change)
Financing	
3PAR	Third-party financing
FIN	Commit sufficient resources; give program its own budget responsibility
PAY	Improve financial modelling (*e.g.,* adjust simple payback criterion; use appropriate discount rate for NPV)
Implementation	
BKM	Adopt best known methods and/or best-practice project management approaches
CAP	Existing employees' capability, competence, and expertise
CSR	Corporate social responsibility policy; pressure from consumers, shareholders, and buyers to be green
EED	Consider an energy-efficient design from the start of each project
EMP	Employees feel empowered and rewarded to take action
EXST	Modify existing infrastructure or systems instead of replacing; handle issues through existing change control process
ISO	Previous ISO experience
SCS	(Momentum from) past successful energy efficiency projects
SILO	Reduce departmental silos; create cross-functional energy teams; share required tools, frameworks, and information
SUPP	Engage with suppliers or others in supply chain around energy management policy
TEAM	Establish empowered energy teams and internal champions (for each facility, if applicable)
TRN	Organize and sponsor relevant trainings
Measurement/Benchmarking/Reporting	
CENT	Centralize energy data collection; centralized and single point person documentation
METR	Determine appropriate metrics (*e.g.,* energy performance indicators, baselines, and benchmarks)
PROC	Use established process, governance, or system to (re)assess progress
VER	Verify energy savings according to principles of ISO 50015 and IPMV; perform complete energy review
TECH	Availability of advanced tools, innovation, and use of new technology

Challenges

Financial	
$	High upfront project costs; insufficient access to capital; lack of financial resources
CYC	Program planning cycles
NPV	Capital budgeting methods do not fully account for capital improvements because they do not use NPV
PBP	Insufficient payback; low cost of energy as share of operating costs; energy price trends favour inaction
TAX	Corporate tax structure
U$	Uncertainty of energy and cost savings realization, difficulty framing EnMS as financially beneficial
Informational	
AWAR	Lack of awareness or failure to recognize benefits of systematic EnMS or non-energy benefits
EMV	Challenges conducting EM&V, the energy review process, or energy accounting
EXP	Lack of in-house expertise; limited access to best practices and outside contractors with necessary expertise
INFO	Imperfect information; lack of disaggregated and transparent energy consumption data
Organizational	
CEO	Lack of ongoing top management support
CUL	Energy management not integrated/rewarded within company culture, nor part of daily employee behavior
DIFF	Certification requirements difficult to achieve, onerous, and distracting
DIR	Lack of policies, goals, and direction that favour energy efficiency investments
DUP	Duplication of effort (*e.g.,* system to manage energy exists so firm is reluctant to implement another)
FIN	Internal competition for capital
GOV	Lack of government/industry programs
OWN	Lack of ownership for energy/carbon emissions within company
RISK	Perceived risk to quality or production
SILO	Departmental silos; misaligned responsibilities & budgets; knowledge gap between departments
SPL	Split incentives (*e.g.*, those using the energy are not the same as those who pay for it)
T	Time commitment required for learning/implementation
TIME	Managers stay in posts only a short time; short business time horizons

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